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Coastal and Hydraulics Laboratory

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Preface

This report presents the results of a numerical model investigation used to further study the average salinity changes that will occur in the Lake Pontchartrain Basin as a result of varying the level of closure of the Mississippi River-Gulf Outlet below Lake Borgne, LA.

This investigation was conducted from February 2002 through April 2002 at the U.S. Army Engineer Research and Development Center (ERDC), Vicksburg, MS, by Dr. R. C. Berger, Mr. A. R. Carrillo, and Ms. J. N. Tate of the Coastal and Hydraulics Laboratory (CHL), and Mr. B. J. Thibodeaux of the U.S. Army Engineer District, New Orleans. Funding was provided by the New Orleans District.

This study is a modification of a previous study conducted from January 2000 through August 2000 at ERDC by Dr. Berger, Mr. Carrillo, and Ms. Maria S. Sarruff of CHL and Mr. Thibodeaux of the New Orleans District (ERDC/CHL TR-01-14, Carrillo et al. 2001).

The work was performed under the general direction of Dr. Robert T. McAdory, Chief, Tidal Hydraulics Branch, CHL, and Mr. Thomas W. Richardson, Director, CHL.

At the time of publication of this report, Dr. James R. Houston was Director of ERDC, and COL John W. Morris III, EN, was Commander and Executive Director.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in figures, plates, and tables of this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
feet	0.3048	meters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

Background

The Mississippi River-Gulf Outlet (MRGO) consists of a ship channel 36 ft deep[1] and 500 ft wide, extending approximately 76 miles from the junction of the Inner Harbor Navigation Canal and the Gulf Intracoastal Waterway in New Orleans, LA, to the -38 mlw[2] contour in the Gulf of Mexico. The purpose of the MRGO is to provide a deep-draft navigation channel to the Port of New Orleans Inner Harbor Facilities directly from the Gulf of Mexico.

Since the MRGO's completion in January 1968, saltwater flux from the MRGO through direct connections to Lake Borgne and the Gulf Intracoastal Waterway has contributed to an increase in the salinity concentration of the lakes and Biloxi Marshes. Attempts by the U.S. Army Engineer District, New Orleans, to mitigate this salinity increase through the operation and maintenance program have met with little or no success.

Therefore, the New Orleans District is participating in an Environmental Protection Agency sponsored study, "Mississippi River - Gulf Outlet, LA, Re-evaluation Study," focusing on the deep-draft navigation, environmental, and flood control aspects of the project and the need for continued maintenance. The purpose of the re-evaluation study is to determine if the existing channel should be modified and to provide the advisability of continuing its operation. In support of the effort, the U.S. Army Engineer Research and Development Center, Waterways Experiment Station Coastal and Hydraulics Laboratory (CHL), was tasked to model several plans for partial blockage of the MRGO south of Lake Borgne, LA.

An initial model study was performed from January 2000 through August 2000 and consisted of a base condition and four levels of closure. The maximum depth in the MRGO cross section is 47 ft. Closure consisted of a sill across the LaLoutre Ridge in the MRGO. Therefore, none of the partial closure plans modified the width; they only reduced the depth. The four closure conditions were as follows:

[1] A table of factors for converting U.S. customary units of measurement to SI is presented on page vi.
[2] All elevations cited in this report are in feet referred to mean low water (mlw).

- 20-ft Plan: Closed to within a 20-ft depth.

- 16-ft Plan: Closed to within a 16-ft depth.

- 12-ft Plan: Closed to within a 12-ft depth.

- Complete closure.

The results of this study showed that these partial closure plans had little effect on the salinity changes in the Biloxi Marshes. The only plan to produce a significant reduction in the salinity in the region was the complete closure plan.

The New Orleans District again tasked CHL to model several new plans for partial closure of the MRGO south of Lake Borgne, LA. These new plans consist of MRGO width reduction in addition to depth reduction.

Objective

The objective of the work presented herein is to evaluate the seasonal maximum, minimum, and mean changes in salinity that will occur in the Mississippi and Louisiana estuaries of the Lake Pontchartrain Basin, particularly that part known as the Biloxi Marshes, resulting from partial depth **and** width closure of the MRGO below Lake Borgne. In order to verify that the MRGO will be able to maintain its navigation purpose, the velocities in the MRGO closure area will also be evaluated.

The purpose of this report is to present the results of the numerical model investigation addressing this objective. The modeled region includes Lake Pontchartrain, Lake Borgne, the MRGO, the Inner Harbor Navigation Channel, the Gulf Intracoastal Waterway (GIWW), the Rigolets, the Chef Menteur segments of the Mississippi Sound, Chandeleur Sound, Breton Sound, and at least a portion of the Biloxi Marshes, as shown in Figure 1.

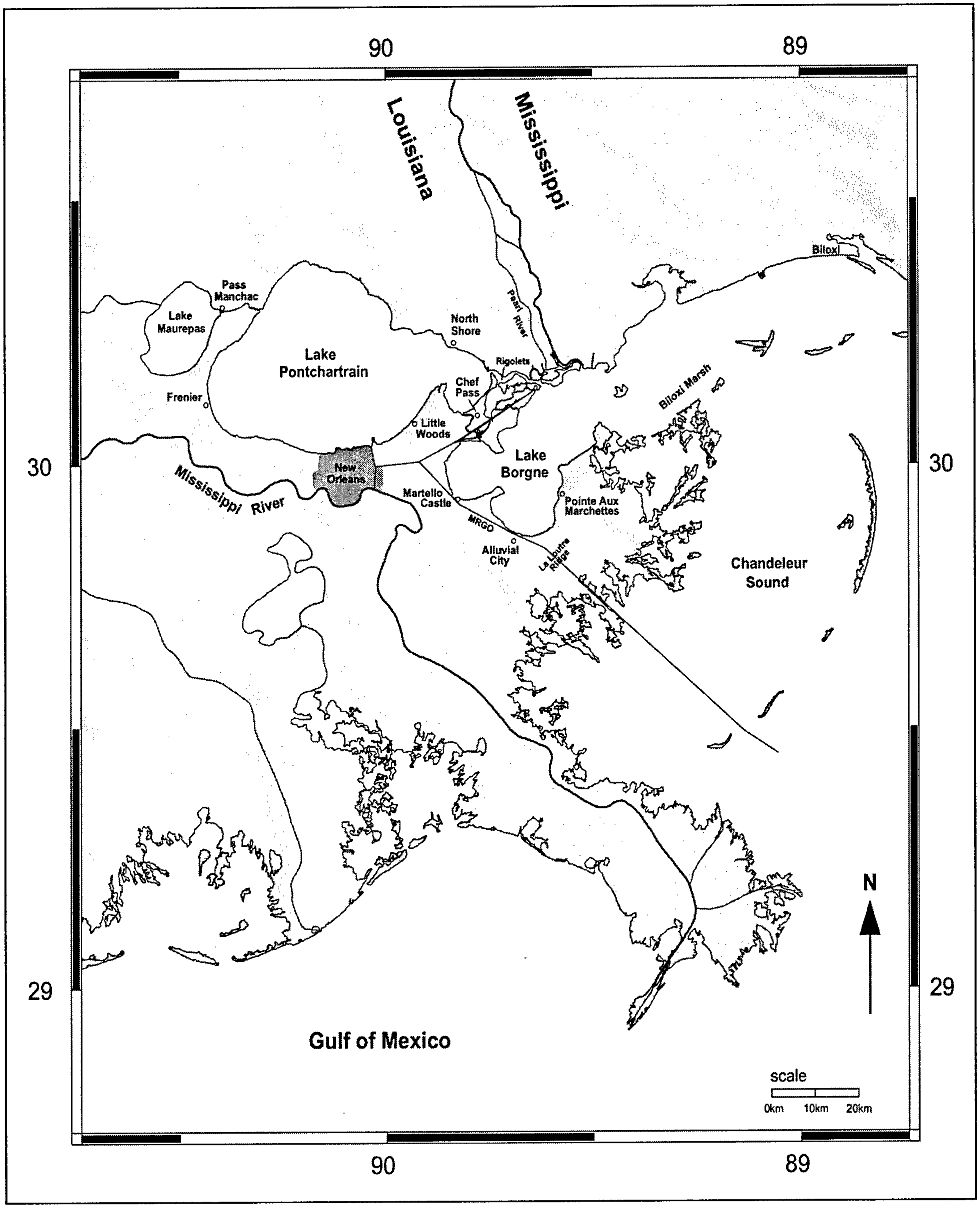

Figure 1. Vicinity map

2 Lake Pontchartrain Basin

The Lake Pontchartrain Basin consists of Lake Maurepas, Lake Pontchartrain, Lake Borgne, the Biloxi Marshes, and Chandeleur Sound, plus associated marshlands and waterways. The Basin is described in detail by the New Orleans District (U.S. Army Engineer District, New Orleans, 1984, 1990), Pankow et al. (1989), and the U.S. Army Corps of Engineers Committee on Tidal Hydraulics (1995). A summary of pertinent factors will be provided here.

Hydrology

The largest tributary to the area is the Pearl River with a mean annual flow of about 10,000 cfs. The Pearl River discharges into Lake Borgne near the mouth of the Rigolets, one of the three tidal waterways out of Lake Pontchartrain. Several smaller rivers, the largest of which are the Amite, Tickfaw, Tangipahoa, and Tchefuncta Rivers, flow into Lake Pontchartrain and Lake Maurepas. The annual freshwater flow into Lake Pontchartrain averages about 3,800 cfs.

Hydrodynamics

Tides in the basin are principally diurnal, with mean ranges of 0.3 ft (Lake Maurepas) to 0.5 ft (Lake Pontchartrain) to 1.4 ft (Chandeleur Sound). Sustained winds can raise or lower peak astronomical tide levels by several feet for short periods. Mean water levels are affected by winds, freshwater runoff, and seasonal trends in the Gulf of Mexico.

Typical seasonal variability in mean water level is illustrated in the monthly mean water levels for 1979-1986 at Biloxi as seen in Figure 2. These levels are representative of Gulf levels throughout the area in that the mean water levels are lower in winter and midsummer while higher in spring and fall.

Currents and circulation are controlled by tides, winds, freshwater discharges, and gulf currents. Flows in the MRGO are also affected to an extent by density currents (Donnell and Letter 1991).

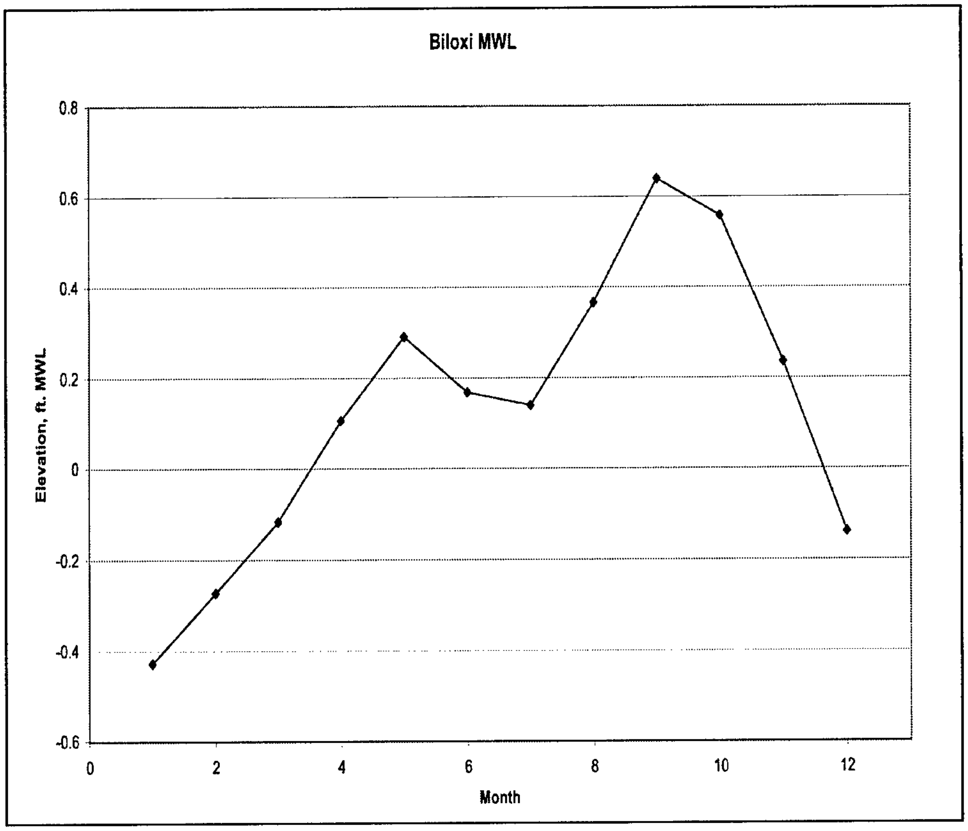

Figure 2. Intra-annual mean water level variation at Biloxi, 1979-1986

Lake Pontchartrain Historical Salinity

Data from five stations in the Pontchartrain Basin were analyzed to obtain historical salinity levels. The five stations are Pass Manchac near Pontchatoula, Lake Pontchartrain at Little Woods, Chef Menteur Pass near Lake Borgne, Lake Pontchartrain at North Shore, and Bayou LaLoutre at Alluvial City. In order to observe changes in the salinity due to the MRGO, the data are arranged in pre- and post-MRGO periods. The majority of the MRGO project was completed in July 1963, but a plug at Paris Road was not removed until 1968. Regardless, instrusion up the MRGO to Lake Borgne was allowed by the conditions between 1963 and 1968.

The data indicate that the salinity is lowest in the late spring and highest in the summer and fall. This is reflective of the seasonal variations in the freshwater inflows from the major rivers and streams into the basin. The salinity in Lake Borgne generally ranges from 2 to 15 ppt and is influenced greatly by Pearl River discharges and inflows from the Rigolets and Chef Pass. Higher salinity water from the MRGO enters Lake Borgne through breaks in the marshes between the two water bodies.

The analyses of the salinity data indicate that the most notable increase in monthly average salinity occurred after 1963. Mean monthly salinity increased for all months for the period after 1963. This increase falls directly after the partial completion of the MRGO in 1963 which provided a major access for salt water to enter Lake Maurepas, Lake Pontchartrain, and Lake Borgne. No other major events occurred at that time to cause such an increase in the salinity.

Monthly summaries of salinity for pre- and post-MRGO indicate that salinity has increased on the average by the following amounts:

- 1.1. ppt at Lake Pontchartrain, North Shore.
- 1.9 ppt at Lake Pontchartrain, Little Woods.
- 0.4 ppt at Pass Manchac near Pontchatoula.
- 2.3 ppt at Chef Menteur Pass near Lake Borgne.
- 4.5 ppt at Bayou LaLoutre, Alluvial City.

The salinity in the region has stabilized, and no significant increase in average annual salinity is projected in the forseeable future for Lake Maurepas and Lake Pontchartrain. Salinity is expected to increase in the Lake Borgne region and surrounding marshes due to land loss in the area.

Table 1 gives the mean monthly pre- and post-MRGO salinity for the period 1951 to 1963 and 1963 to 1977.

Table 1
Pre- and Post-MRGO Salinity (ppt)

	Pass Manchac		North Shore		Little Woods		Chef Pass		Alluvial City	
Month	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
January	1.1	1.5	3.0	4.0	3.9	5.0	3.8	5.7	6.8	9.8
February	1.0	1.5	2.5	3.0	3.0	6.5	2.9	4.8	6.4	9.7
March	1.0	1.2	1.9	2.6	2.3	4.4	2.2	4.3	6.3	10.4
April	0.8	1.3	1.9	2.6	2.4	4.0	2.2	4.0	7.0	10.0
May	1.0	1.1	2.4	2.7	2.2	3.9	2.6	4.0	9.5	10.2
June	1.0	1.5	3.6	3.0	2.2	3.8	3.3	4.2	9.0	12.3
July	1.0	1.6	3.0	4.6	2.1	4.4	3.2	6.3	7.9	16.0
August	1.2	1.7	4.6	5.6	2.5	4.8	4.8	7.5	8.6	16.1
September	1.7	2.0	5.4	7.5	4.5	6.2	6.0	8.5	8.2	12.9
October	1.8	2.2	4.7	7.3	4.9	6.8	5.2	8.4	7.6	13.8
November	1.8	2.1	4.6	6.7	4.8	6.8	5.2	8.0	8.0	13.1
December	1.2	1.8	4.5	5.4	4.7	6.2	4.2	7.0	8.0	12.5

3 Approach

Numerical Method

TABS-MDS, the numerical model used for this investigation, is a three-dimensional, finite-element code originally developed by Dr. Ian King of Resource Management Associates, and modified at ERDC. It models three-dimensional hydrodynamics and salt transport accounting for unsteady river inflows, tides, wind effects, and density-driven circulation. It has been widely used at ERDC to model three-dimensional hydrodynamics and salinity at numerous locations, including Galveston Bay, TX (Berger et al. 1995).

Computational Mesh

Figures 3-6 illustrate the planform view of the computational meshes used in the original and the current studies, respectively. All meshes are identical except in the area of closure. They are three-dimensional everywhere except near the gulfward boundary and in Lake Maurepas. The grid is refined along the MRGO and its connections to the Gulf of Mexico, Lake Borgne, and Lake Pontchartrain. The computational mesh provides direct connections between MRGO and Lake Borgne at Shell Beach and Martello Castle. Another connection exists between Lake Borgne and the GIWW near Bayou Gentilly (southeast of Chef Menteur). These connections are sized to approximate not only the connections at those locations, but also nearby smaller connections, and thus represent an aggregation of several smaller waterways.

The new study reduces the width of the MRGO at the point of depth closure, so the meshes used for the current study contain a narrow pass through the MRGO as seen in Figures 4-6. The contraction is placed at approximately the midpoint of the previous region of closure and extends for roughly 300 ft. The profile slope up to the closure sill is gradual, on the order that the natural slope might be (approx. 1 vertical to 1,000 horizontal). The lateral side slopes in nature are to be 1 vertical on 3 horizontal, which cannot easily be accomplished in a numerical model. This could involve moving the grid horizontally to follow the water surface. Instead, researchers rely upon a fixed grid that approximates these configurations for side slope. The given base width is provided and the 1 vertical on 3 horizontal side slope is maintained to a depth such that the region will remain wet throughout the simulation. A vertical wall is then assumed at this location. In the case of the 12-ft sill elevation, a closure width was chosen

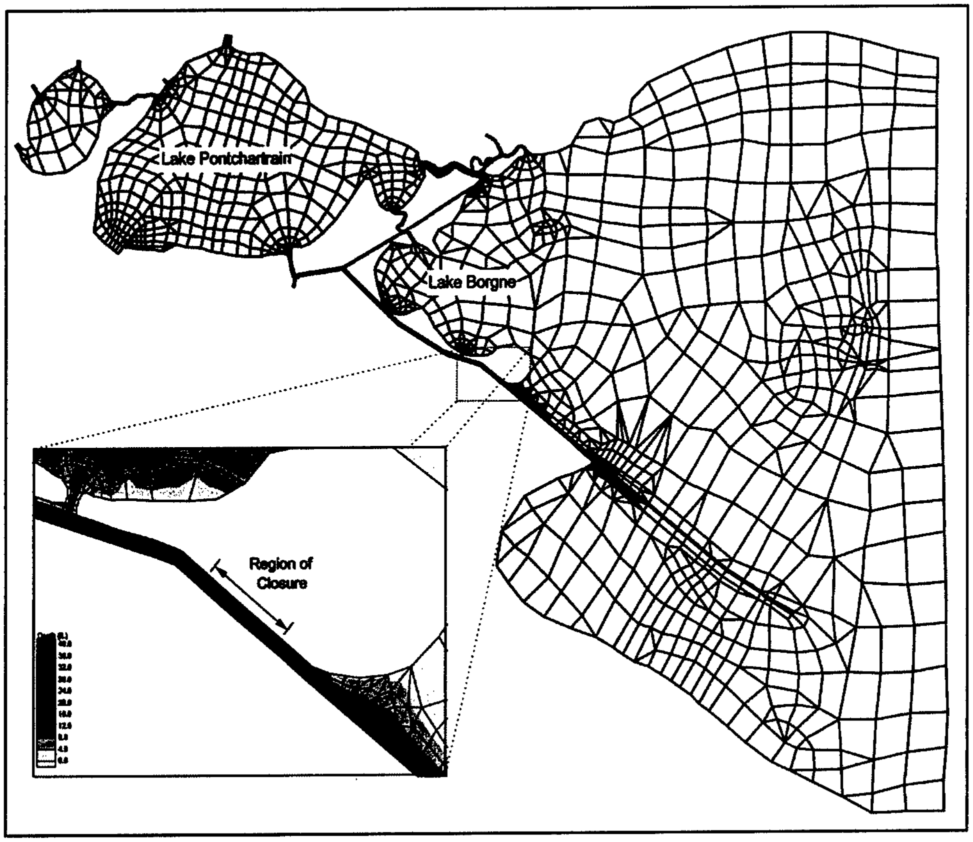

Figure 3. Base plan mesh

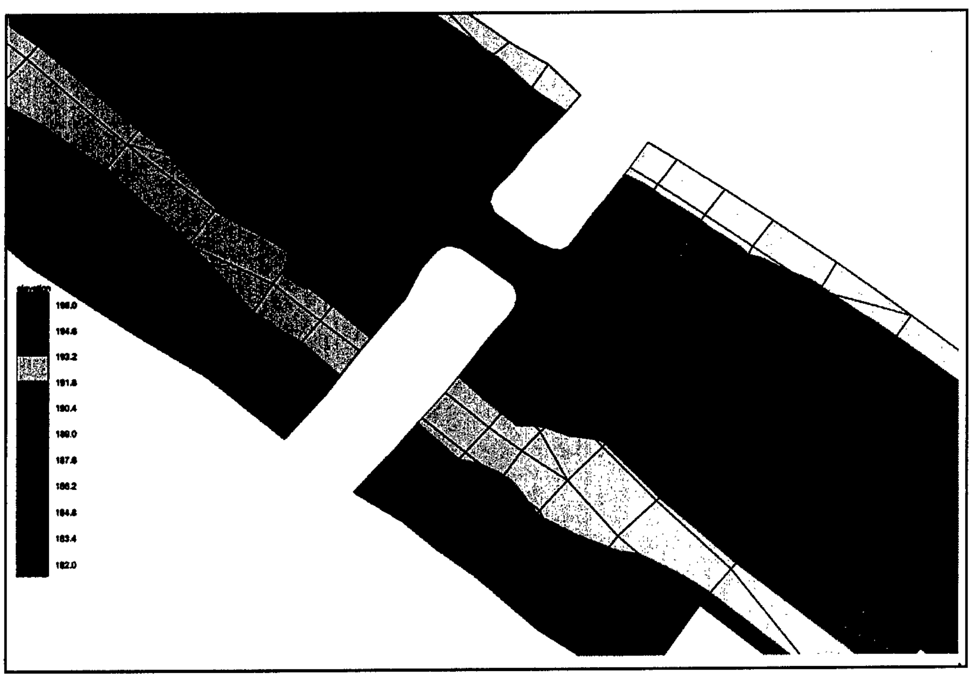

Figure 4. 125-ft width by 12-ft depth

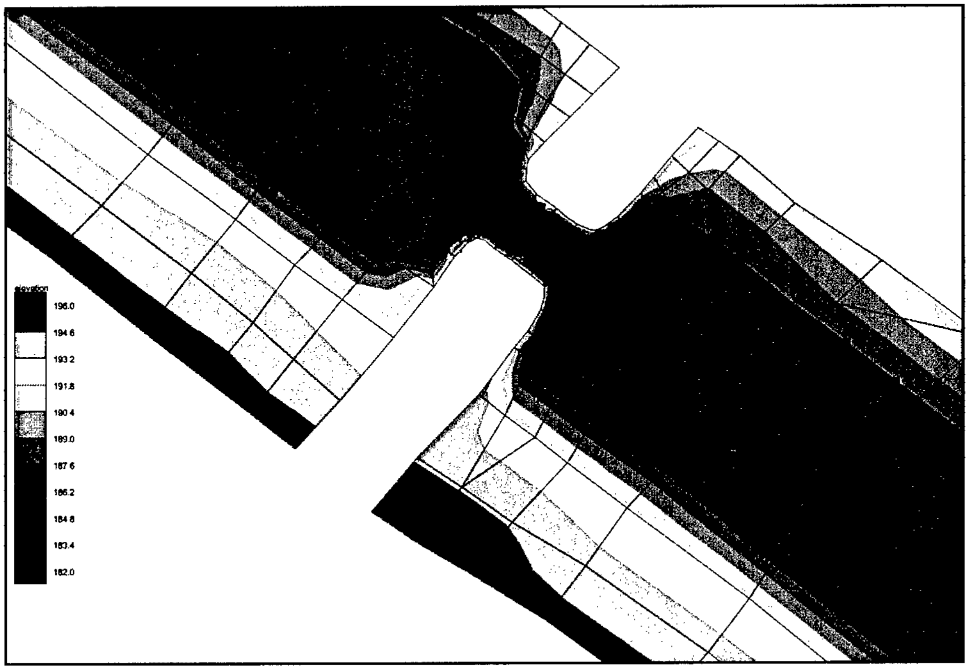

Figure 5. 160-ft width by 16-ft depth

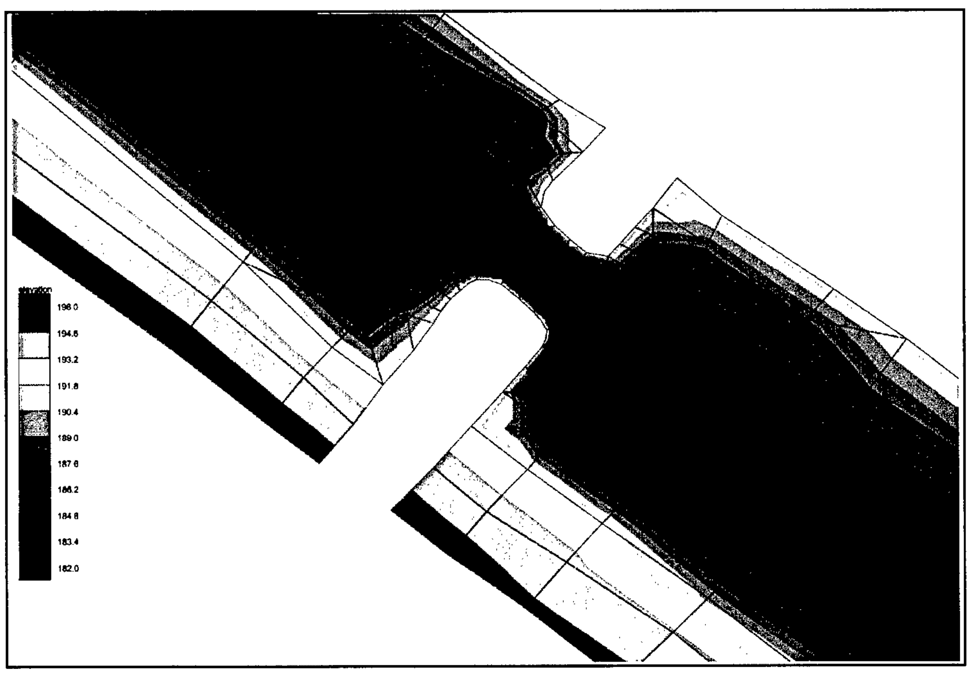

Figure 6. 200-ft width by 20-ft depth

that approximated the width for the average cross-sectional area for a rectangular section, i.e. no side slopes which would yield gradients too extreme for the numerical model. This meant that the width as modeled was actually 151 ft at the base rather than 125 ft and matches the cross-sectional area precisely at a water surface elevation of 0 ft mlw.

Model Validation

Validation for the Lake Pontchartrain Basin model was performed in a prior investigation. Details of the validation can be found in McAnally and Berger (1997).

Experimental Conditions

Typical modeling conditions for the base and plan experiments are based on statistical measures. Since most of this work is based on prior investigations, only a brief discussion of the specifics of the experimental conditions are addressed in the following sections. For a more detailed discussion, see McAnally and Berger (1997).

Boundary Conditions

Riverflows for base and plan experiments

Base and plan experiments were conducted for typical conditions, using the 50-percent exceedence flows given in Table 2 and based on U.S. Geological Survey data from 1982 and 1985-1987. These have been corrected for ungauged areas. A complete description of the development of the flows used for the model is given in McAnally and Berger (1997).

Table 2
Stream Inflow (cfs) for Model Programs

Month	Pearl	Amite	Blind	Tangipahoa	Tickfaw	Tchefuncta
January	9,602	2,194	216	1,160	512	175
February	18,060	2,689	216	1,480	674	222
March	19,120	2,842	216	1,533	676	214
April	15,510	2,142	216	1,223	514	170
May	10,090	1,402	216	853	325	118
June	4,178	713	216	556	158	66
July	3,522	702	216	581	147	69
August	2,792	579	216	495	145	66
September	2,388	499	216	475	137	60
October	2,047	448	216	390	87	46
November	2,651	463	216	413	125	68
December	5,339	1,468	216	912	362	137

Tides

Tides at the model's gulfward boundary were synthesized for the year 1982 from the tidal constituents as given by Outlaw (1982) and shown in Table 3. The mean water level set to zero referred to the National Geodetic Vertical Datum (NGVD).

Table 3
Gulf Boundary Tidal Constituents

Tidal Constituents		South End of the Boundary		South of Ship Island		North End of the Boundary	
Component	Period, hr	Amplitude, ft	Epoch, deg	Component	Period, hr	Amplitude, ft	Epoch, deg
01	25.819	0.46	-37.4	0.51	-37.4	0.36	-50.4
K1	23.934	0.47	-38.6	0.51	-38.8	0.36	-50.2
P1	24.066	0.15	305.6	0.15	310.3	0.14	289.1
M1	24.833	0.01	323.7	0.02	328.2	0.00	329.1
J1	23.099	0.02	282.7	0.02	267.1	0.02	289.1
Q1	26.868	0.11	-40.8	0.12	-39.5	0.07	-57.5
M2	12.421	0.09	239.5	0.09	252.9	0.04	214.4
S2	12.000	0.05	264.1	0.05	284.8	0.03	235.0
N2	12.658	0.02	209.4	0.02	223.0	0.01	183.8

Wind

The wind data used were obtained from the U.S. Air Force Environmental Technical Applications Center in Ashville, NC. These data are the hourly surface winds at the New Orleans International Airport for the calendar year 1982 and are used for all base and plan experiments.

Initial Conditions

In these experiments an initial salinity field, currents, and water elevations were obtained from previous simulations of the region (McAnally and Berger 1997) and used as initial conditions for all base and plan experiments. Since the simulations were started in January, the initial conditions have sufficient relaxation time before the first period of interest in April.

Base and Plans

The base condition of a maximum depth in the MRGO cross section of 47 ft is maintained, and three combinations of depth and width closure are modeled. Closure consists of a sill across the LaLoutre Ridge in the MRGO and a section of surface width reduction at approximately the midpoint of the length of the ridge and extending for 300 ft along the ridge. All plans employed the boundary and initial conditions described previously and used in the earlier investigations. The experimental conditions were as follows:

- Base: Maximum depth in the cross section is 47 ft.
- 200-ft by -20-ft Plan: Closed to within 20-ft depth and 200-ft width.
- 160-ft by -16-ft Plan: Closed to within 16-ft depth and 160-ft width.
- 125-ft by -12-ft Plan: Closed to within 12-ft depth and 125-ft width.

The numerical model calculates water-surface elevations, current velocities (three-dimensional components), and salinities at each node every 60 min for the 10-month period of simulation between January 1 and October 31. Those data are processed to provide average monthly salinity contour plots for base and each plan for April, May, September, and October (Plates 1-4).

4 Results and Discussion

The purpose of this investigation was to determine the effect of the combined depth and width closures of MRGO on salinities in Lake Pontchartrain, Lake Borgne, and Biloxi Marsh. The results are contained in Plates 1-4. These plates contain the monthly average isohalines for the bottom depth for each plan. The isohalines shown for each plan represent the change from the base conditions. The base conditions are the month's average salinity. The plan isohalines are then changes from base, where a negative sign (-) indicates the closure reduced the salinity and a positive sign (+) indicates an increase in salinity. The averages are given for April, May, September, and October. Tables 4-7 give the values for specific station locations (approximate); all locations are given on Figure 1. The spring months are representative of the low salinity period and the autumn months, the high salinity period. The complete closure results from the prior study are included in this report as well to make comparisons easier.

Table 4
April Monthly Average Salinity (ppt) Changes

Location	Base	200 ft by 20 ft	160 ft by -16 ft	125 ft by -12 ft	Closure
Alluvial City	16.5	-1.8	-3.1	-3.9	-6.0
Chef Pass	8.4	-0.7	-1.1	-1.3	-1.7
Fenier	4.6	-0.2	-0.4	-0.4	-0.6
Little Woods	5.9	-0.8	-1.2	-1.4	-1.6
Martello Castle	15.1	-2.5	-3.9	-4.8	-6.6
North Shore	5.4	-0.5	-0.7	-0.8	-0.9
Pass Manchac	0.7	-0.1	-0.1	-0.1	-0.1
Pointe Aux Marchettes	13.9	0.1	-0.1	-0.2	-0.5

Table 5
May Monthly Average Salinity (ppt) Changes

Location	Base	200 ft by 20 ft	160 ft by -16 ft	125 ft by -12 ft	Closure
Alluvial City	16.1	-1.6	-2.7	-3.5	-5.7
Chef Pass	8.9	-0.8	-1.3	-1.6	-2.2
Fenier	4.7	-0.3	-0.5	-0.6	-0.8
Little Woods	6.2	-1.0	-1.5	-1.7	-2.1
Martello Castle	15.1	-2.2	-3.5	-4.4	-6.6
North Shore	5.7	-0.6	-0.9	-1.0	-1.2
Pass Manchac	0.6	-0.1	-0.1	-0.1	-0.1
Pointe Aux Marchettes	14.3	0.0	-0.2	-0.3	-0.8

Table 6 September Monthly Average Salinity (ppt) Changes					
Location	Base	200 ft by 20 ft	160 ft by -16 ft	125 ft by -12 ft	Closure
Alluvial City	17.9	-1.9	-2.9	-3.5	-5.1
Chef Pass	10.5	-0.6	-0.9	-1.1	-1.6
Fenier	4.9	-0.6	-0.8	-1.0	-1.3
Little Woods	7.1	-1.0	-1.5	-1.8	-2.3
Martello Castle	16.7	-2.2	-3.3	-3.9	-5.4
North Shore	6.9	-0.5	-0.8	-1.0	-1.3
Pass Manchac	1.0	-0.1	-0.2	-0.2	-0.9
Pointe Aux Marchettes	15.8	-0.1	-0.2	-0.4	-0.8

Table 7 October Monthly Average Salinity (ppt) Changes					
Location	Base	200 ft by 20 ft	160 ft by -16 ft	125 ft by -12 ft	Closure
Alluvial City	20.2	-2.3	-3.6	-4.4	-6.6
Chef Pass	11.7	-0.7	-1.1	-1.3	-1.9
Fenier	5.4	-0.7	-1.0	-1.2	-1.6
Little Woods	8.1	-1.4	-2.0	-2.4	-3.1
Martello Castle	19.3	-2.7	-4.2	-5.1	-7.2
North Shore	7.4	-0.6	-0.9	-1.0	-1.4
Pass Manchac	1.1	-0.2	-0.2	-0.3	-0.4
Pointe Aux Marchettes	17.3	-0.1	-0.3	-0.5	-1.1

The base isohalines are found on part (a) of Plates 1-4. The spring months show salinity values in Lake Borgne to be between 8 and 16 ppt. For Lake Pontchartrain, the average spring month salinities are between 4 and 6 ppt. The average autumn salinity values range between 12 and 20 ppt in Lake Borgne and between 4 and 8 ppt in Lake Pontchartrain.

The depth and width closure produced a decrease in the salinity values at locations of interest. As one would expect, the partial width/depth closure plans reduce salinity in Lake Pontchartrain and Lake Borgne, and their reductions are less than that of complete closure. The most severe partial closure plan (125 ft by -12 ft), as expected, produced the changes most nearly like that of complete closure. The least severe partial closure plan had the least impact.

The partial closures in this study included a width reduction in addition to the previously studied depth reduction. The changes in the salinity with the combined depth and width closure (current study) are compared to those for the depth closure alone (previous study) in Table 8 for May and October at locations of interest. Negative values indicate a greater reduction in the salinity for the combined depth and width closure of the MRGO while positive values indicate that the depth closure alone reduced the salinity by a greater amount. This comparison points out that the width reductions are most significant in reducing the salinity intrusion via MRGO.

Table 8
Change in the Salinity Reduction for Depth and Width Closure Compared to the Depth Reduction Alone

	May			October		
Location	**-20 ft**	**-16 ft**	**-12 ft**	**-20 ft**	**-16 ft**	**-12 ft**
Alluvial City	-1.2	-2.3	-3.0	-1.8	-3.0	-3.7
Chef Pass	-0.6	-1.1	-3.0	-0.5	-0.9	-1.0
Fenier	-0.2	-0.4	-0.5	-0.5	-0.8	-1.0
Little Woods	-0.7	-1.2	-1.3	-1.1	-1.7	2.0
Martello Castle	-1.6	-2.8	-3.6	-2.2	-3.6	-4.3
North Shore	-0.4	-0.7	-0.8	-0.4	-0.7	-0.8
Pass Manchac	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2
Pointe Aux Marchettes	+0.1	-0.1	-0.3	0.0	-0.2	-0.4

The velocities in and around the location of partial closure were analyzed to determine the percentage of timesteps in exceedance of a particular value and are shown in Figure 7. The values were chosen as 0.5-ft/sec increments from 0 to 4 ft/sec. The velocities are given as magnitudes based on horizontal and vertical components at a particular surface node in the contraction. The base velocity at approximately the same location is shown for the purpose of comparison.

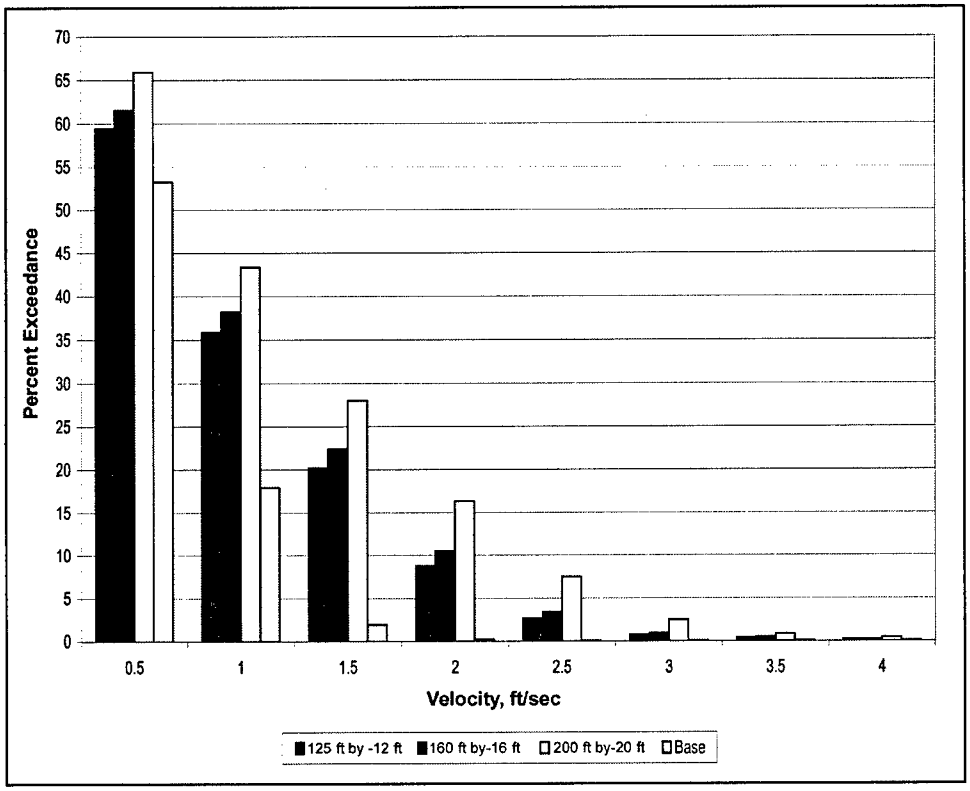

Figure 7. Percent exceedence of velocity in closure area

Note that the velocity magnitudes are lowest in the 125-ft by -12-ft plan, and the velocity magnitudes are greatest in the 200-ft by -20-ft plan. Typically, as the cross-sectional area of an opening decreases, the velocity through it must

increase in order to conserve mass and energy. In this case, however, the magnitude of the velocity is driven by the water-surface differential across the structure and the efficiency of the structure. A large structure is more efficient so that the velocity magnitude may tend to be larger. At some point the structure becomes large enough that the flow through it is sufficient to significantly reduce the water-surface differential. This then will tend to reduce the current magnitude as the structure is enlarged further. In fact, the base, which is more open, has a lower velocity.

Note that the peak flood and ebb velocity for a typical tide will occur at the 8-percent exceedance level. The peak flood and ebb velocity on a typical spring tide will occur at the 0.56-percent level. The 8-percent exceedance level results in an exceedance velocity of 2.04 ft/sec, 2.14 ft/sec, and 2.46 ft/sec for the 125-ft by -12-ft, 160-ft by -16-ft, and the 200-ft by -20-ft plans, respectively. The 0.56-percent exceedance level results in a velocity of 3.25 ft/sec, 3.35 ft/sec, and 3.75 ft/sec for the 125-ft by -12-ft, 160-ft by -16-ft, and the 200-ft by -20-ft plans, respectively.

The velocities for each partial closure plan and the base condition are given in Figures 8-11. There were instances in which the velocities exceeded 4 ft/sec. These large velocities averaged 16 ft/sec in the contraction region. Such large values in the contraction at three specific timesteps are due to winds blowing in excess of 50 mph along the same line as the MRGO at those times. The model applies a uniform wind boundary condition over the entire domain and for the entire hour-long timestep, possibly causing the solution to exaggerate the event. However, if such an event were to occur, these velocities are accurate. Figure 12 shows the water surface for the entire mesh, and Figure 13 shows the velocitiy vectors in the region of closure for one of the high wind events. It can be observed that the water surface is low behind sheltered areas (like the islands) and on the banks in the direction from which the wind is blowing. The water level is high at the bank in the direction to which it is blowing. The particular event from which these figures were generated is caused by a wind speed of 59 ft/sec blowing from the east-southeast, or at an angle of 150 deg from the positive "x" axis. The vector pattern produced is reasonable and expected for the conditions at this timestep.

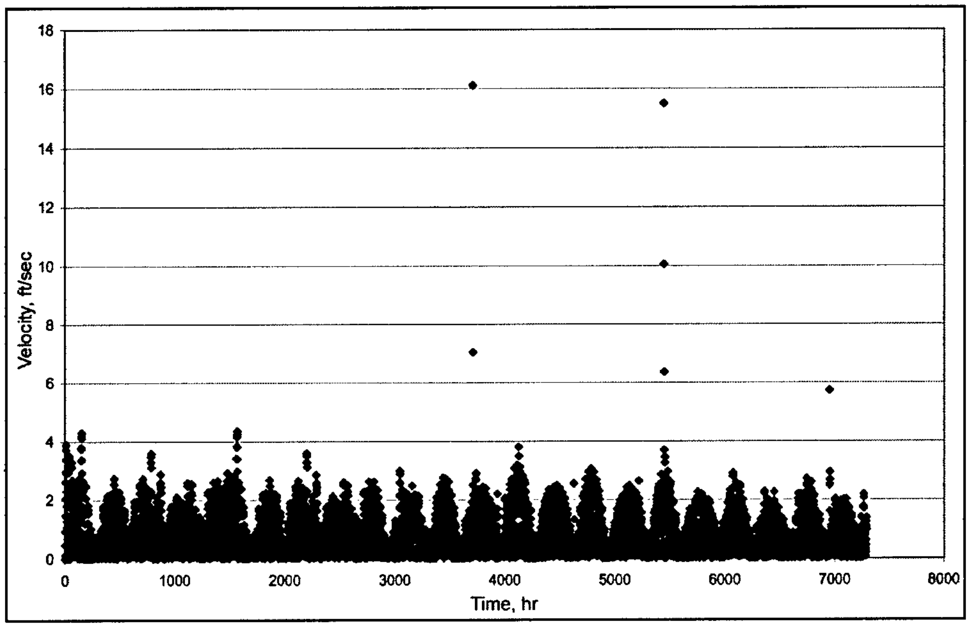

Figure 8. Velocities, 125-ft by -12-ft Plan

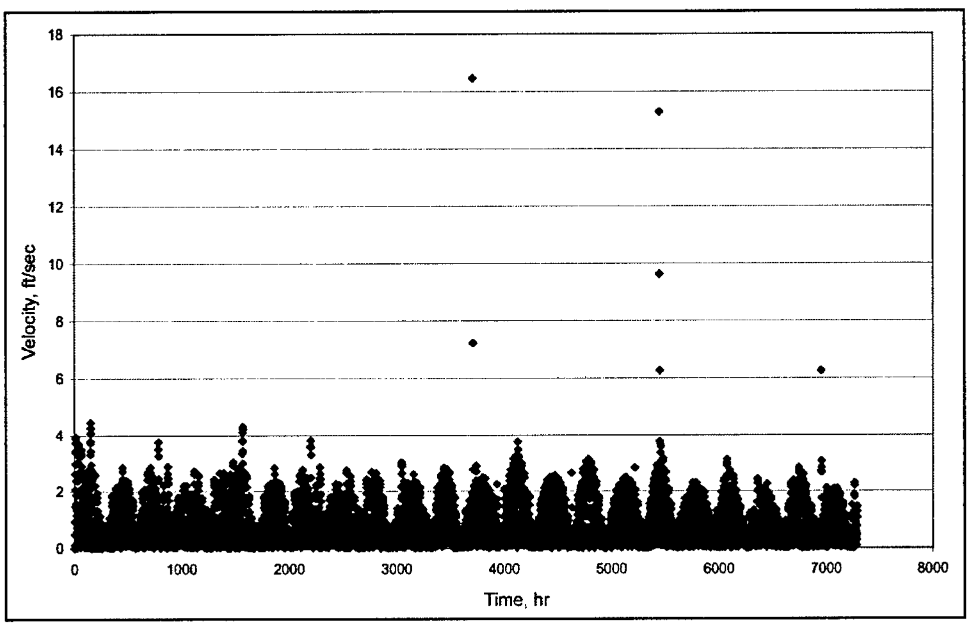

Figure 9. Velocities, 160-ft by -16-ft Plan

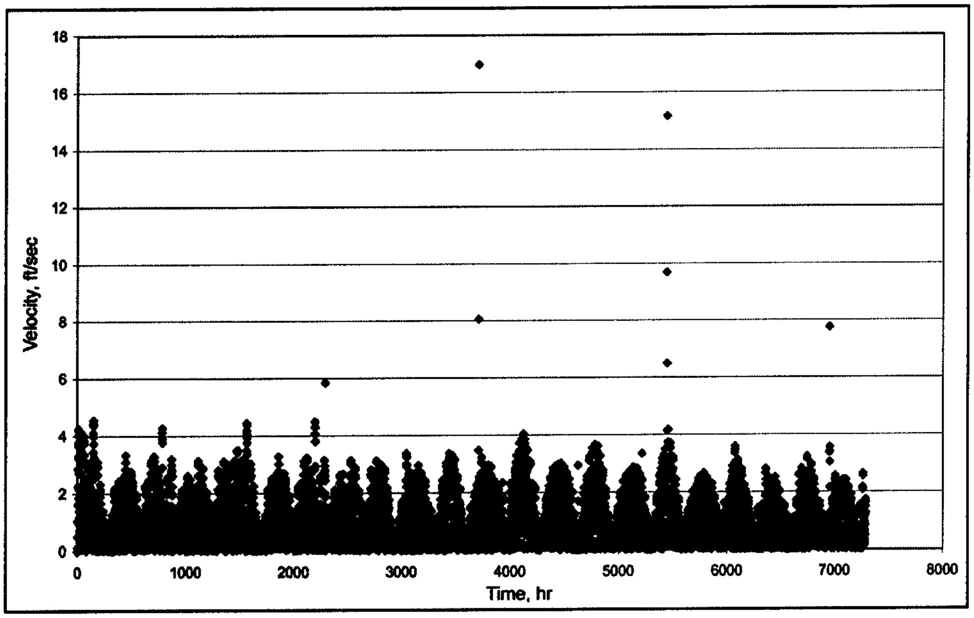

Figure 10. Velocities, 200-ft by -20-ft Plan

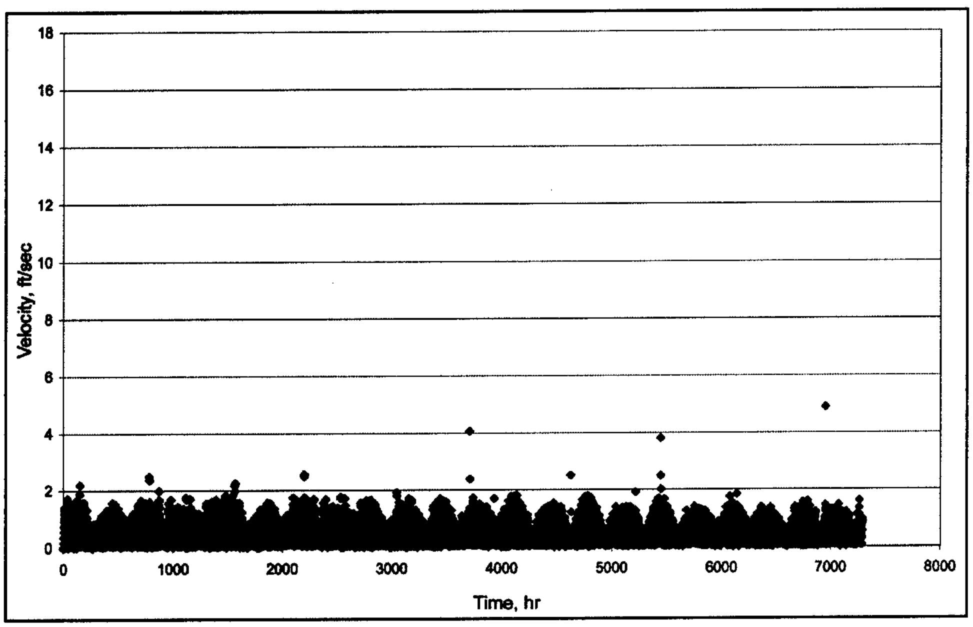

Figure 11. Velocities, Base Plan

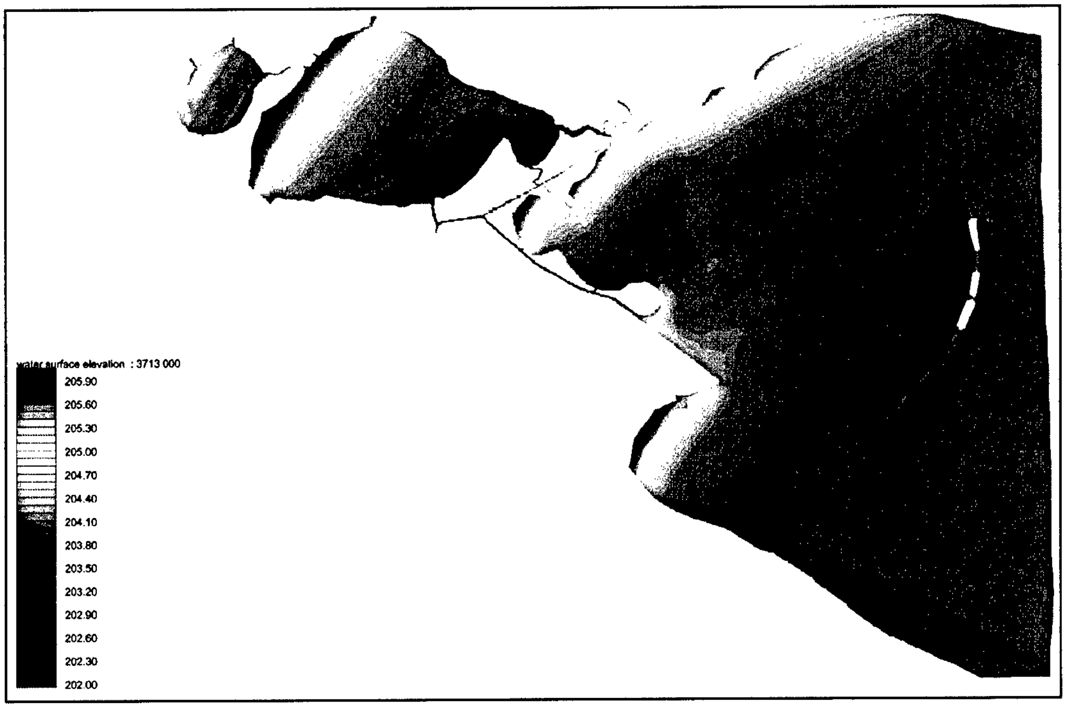

Figure 12. Water surface for high wind event

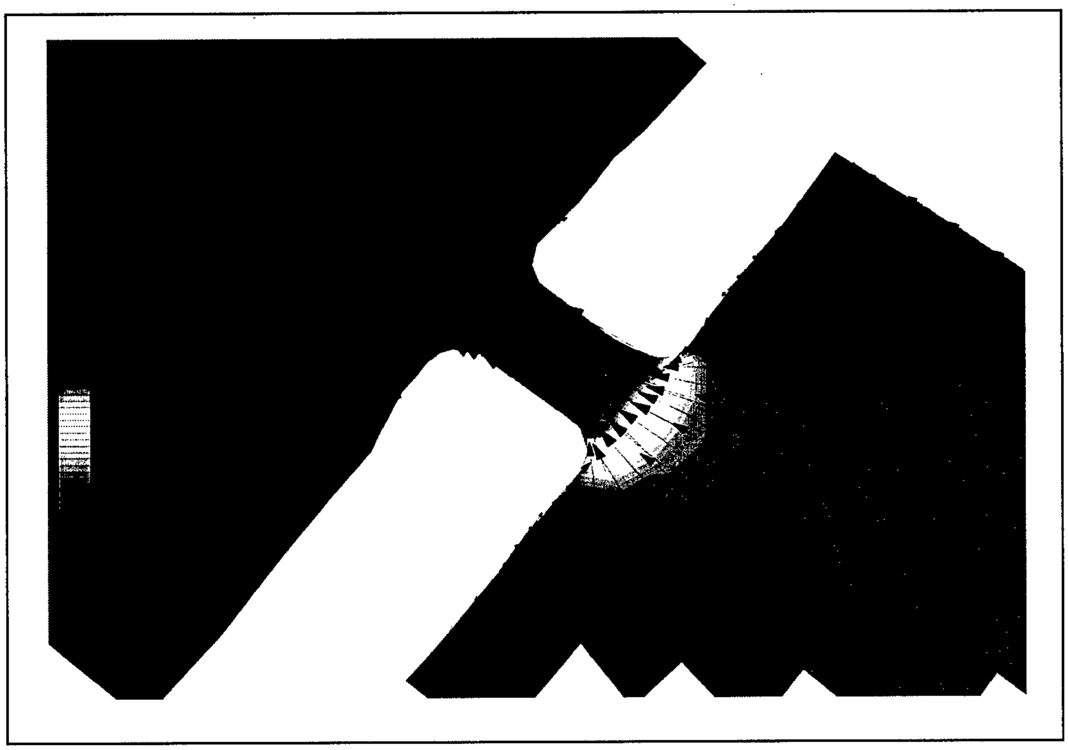

Figure 13. Velocity vectors for high wind event

5 Conclusions

This investigation is concerned with various combinations of depth and width reduction of the MRGO channel from the Gulf of Mexico to the city of New Orleans. Historical records indicate that when the channel was built, the salinity in Lake Pontchartrain and Lake Borgne increased. A previous study concluded that the effects of depth reduction alone along the La Loutre Ridge in the MRGO were insignificant in the reduction of the salinity in Lake Borgne and Lake Pontchartrain. This numerical model study used a sill along the same ridge near the connection of MRGO to the Gulf of Mexico with an elevation of -20 ft mlw for a contraction width of 200 ft, -16 ft mlw for a 160-ft contraction, and -12 ft mlw for a 125-ft contraction. The study is intended to investigate the restoration of the historical salinity regime. The study includes the base condition of a fully open channel and the completely closed MRGO channel.

The salinity reduction in Lake Pontchartrain and Lake Borgne with the partial depth and width closure was much greater than that for the previous study of depth reduction alone. All of the closure plans reduced the salinites in the region and two of the three partial closure plans averaged salinity reductions that exceeded half of the complete closure reduction. The velocities in the contraction region did increase from the base plan. High wind events can cause large velocities in the MRGO contraction.

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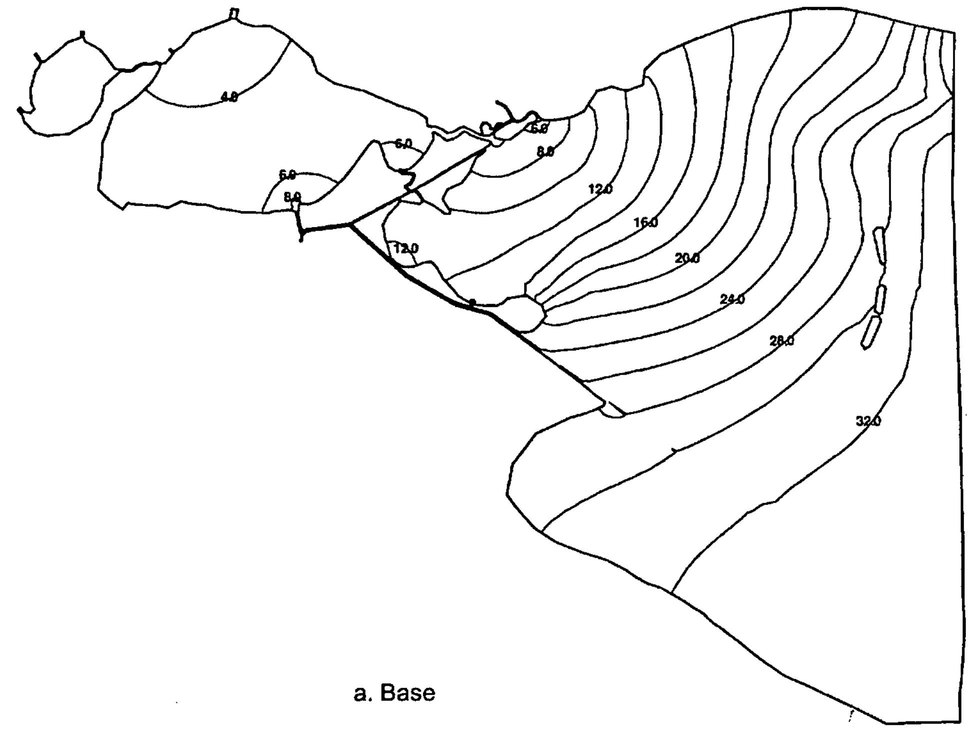

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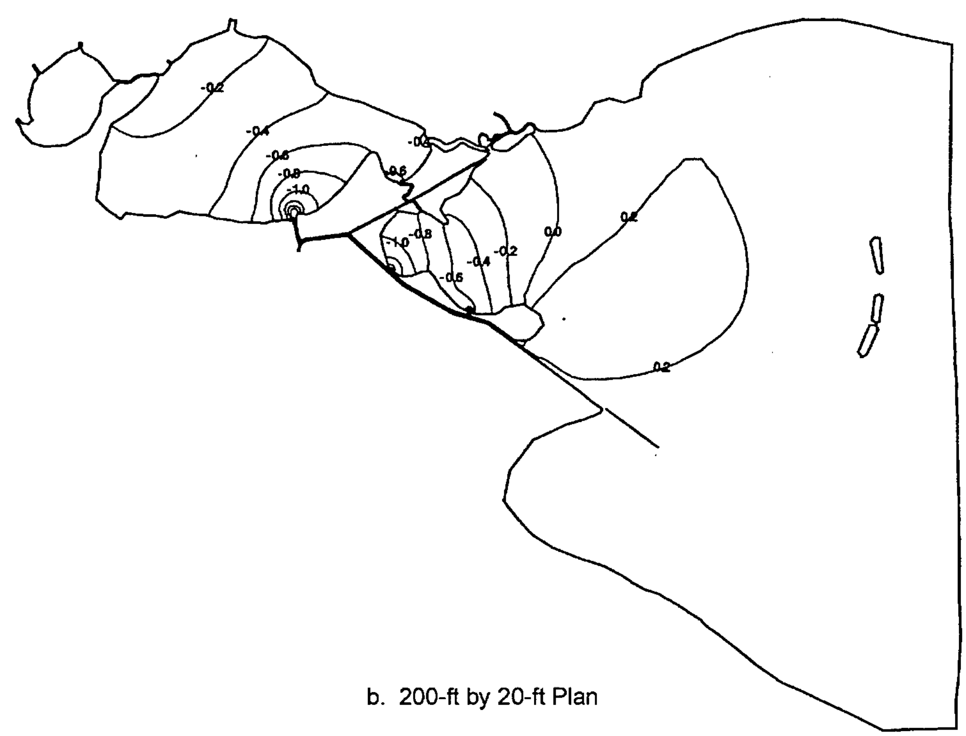
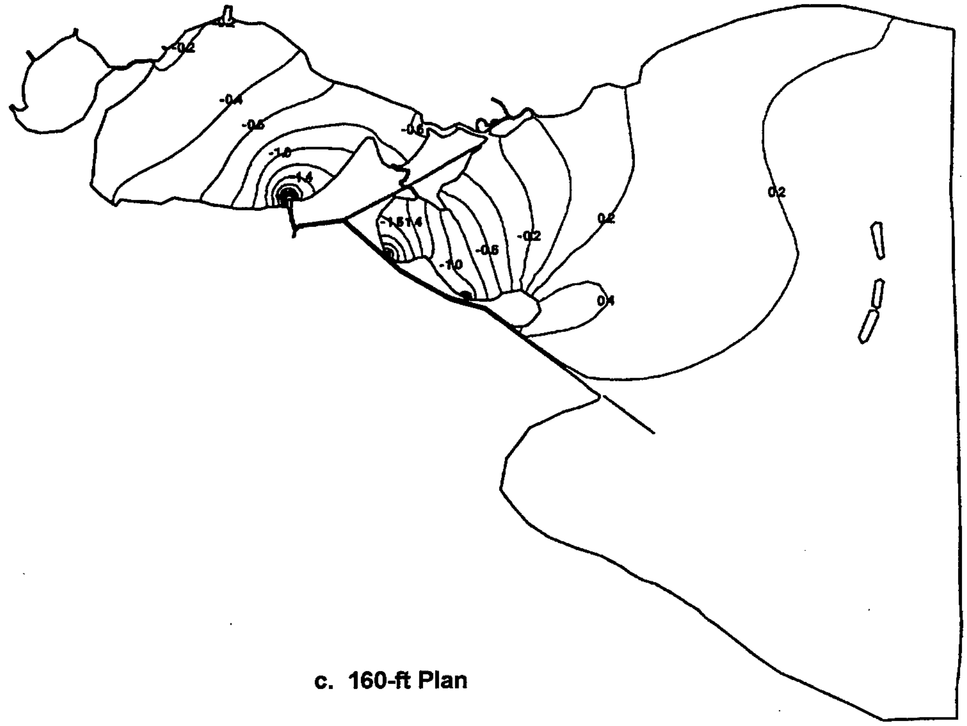


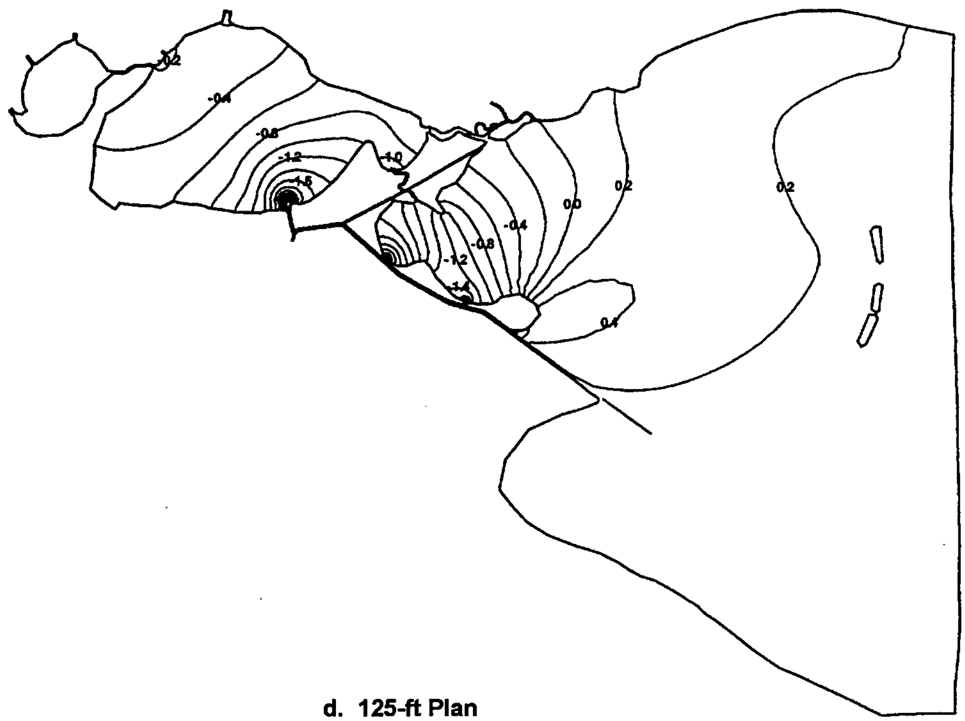
b. 200-ft by 20-ft Plan

Pontchartrain Basin Isohalines
Base and Plans
April

Plate 1
(Sheet 1 of 3)



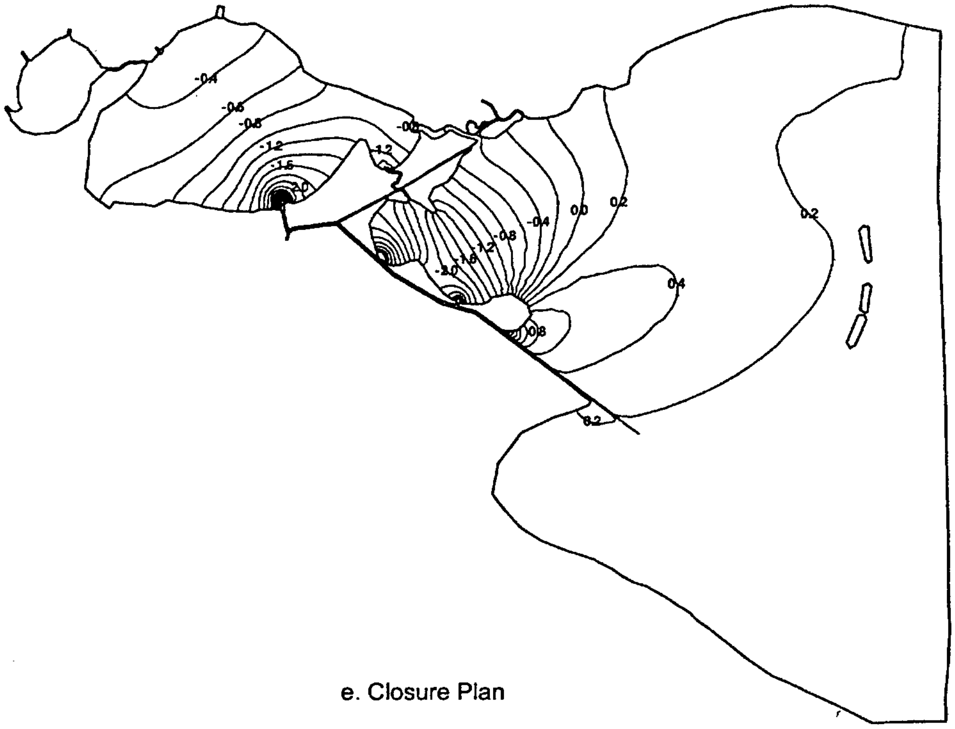
c. 160-ft Plan



d. 125-ft Plan

Pontchartrain Basin Isohalines
Base and Plans
April

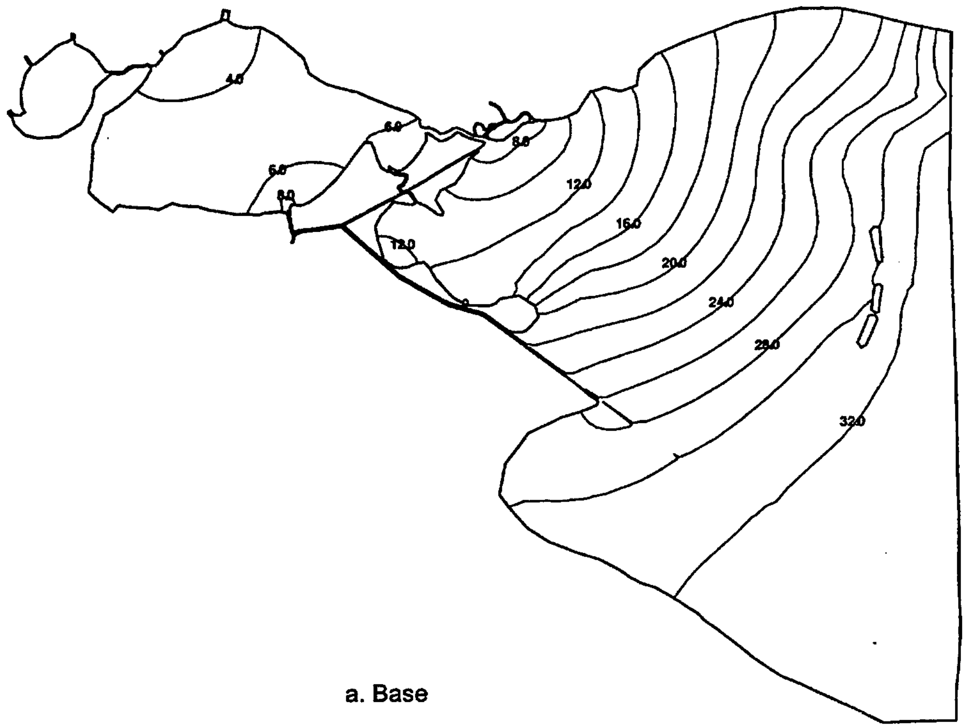
Plate 1
(Sheet 2 of 3)



e. Closure Plan

Pontchartrain Basin Isohalines
Base and Plans
April

Plate 1
(Sheet 3 of 3)



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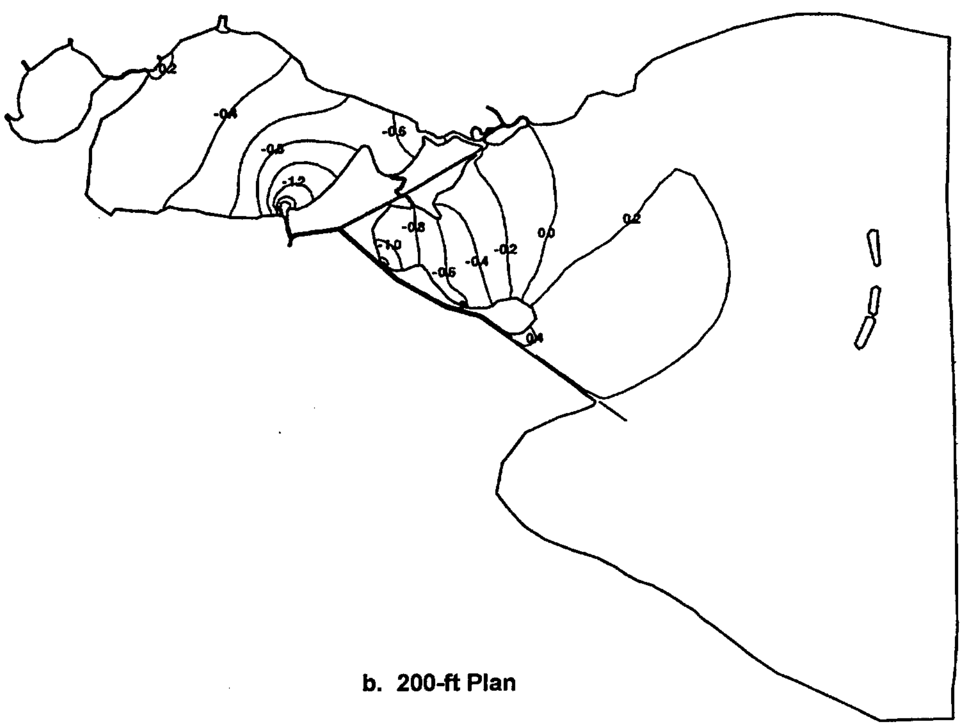
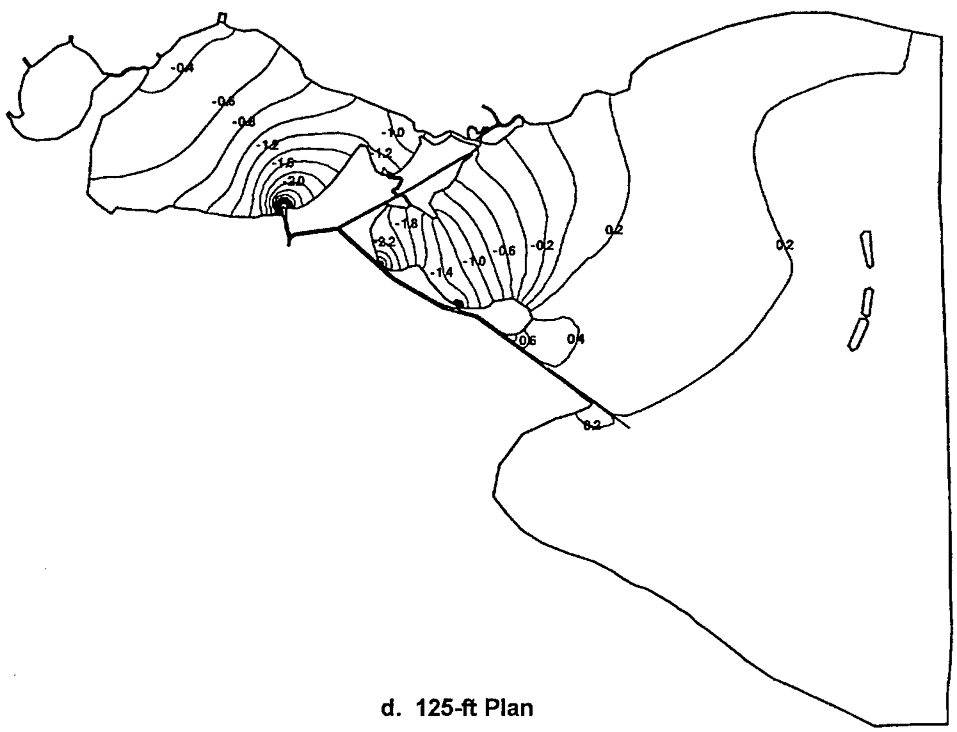


b. 200-ft Plan

Pontchartrain Basin Isohalines
Base and Plans
May

Plate 2
(Sheet 1 of 3)

c. 160-ft Plan



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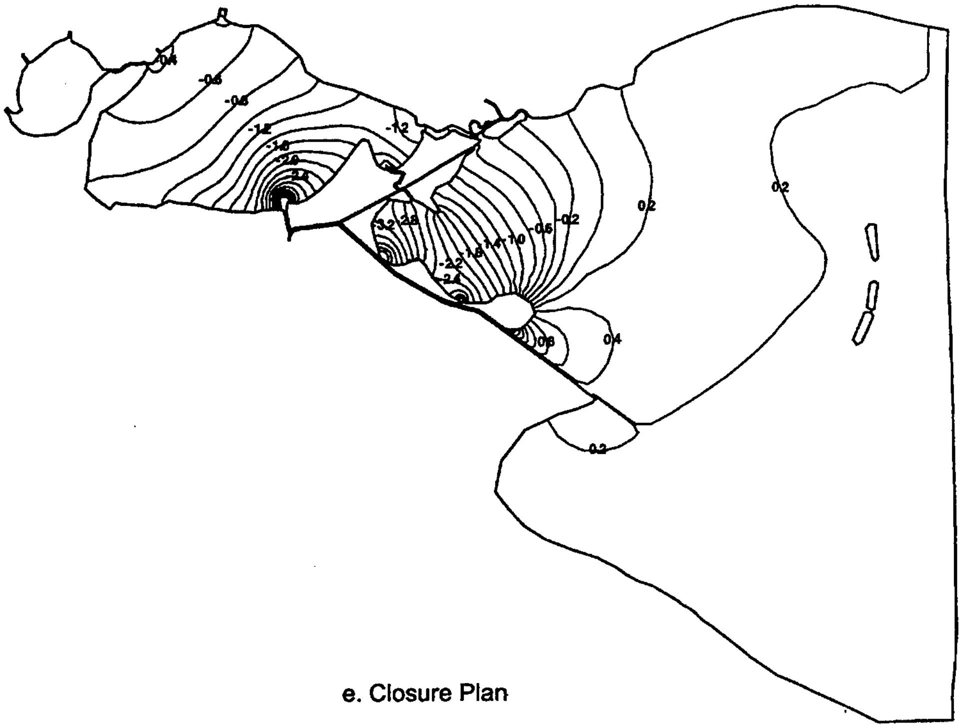
Pontchartrain Basin Isohalines
Base and Plans
May

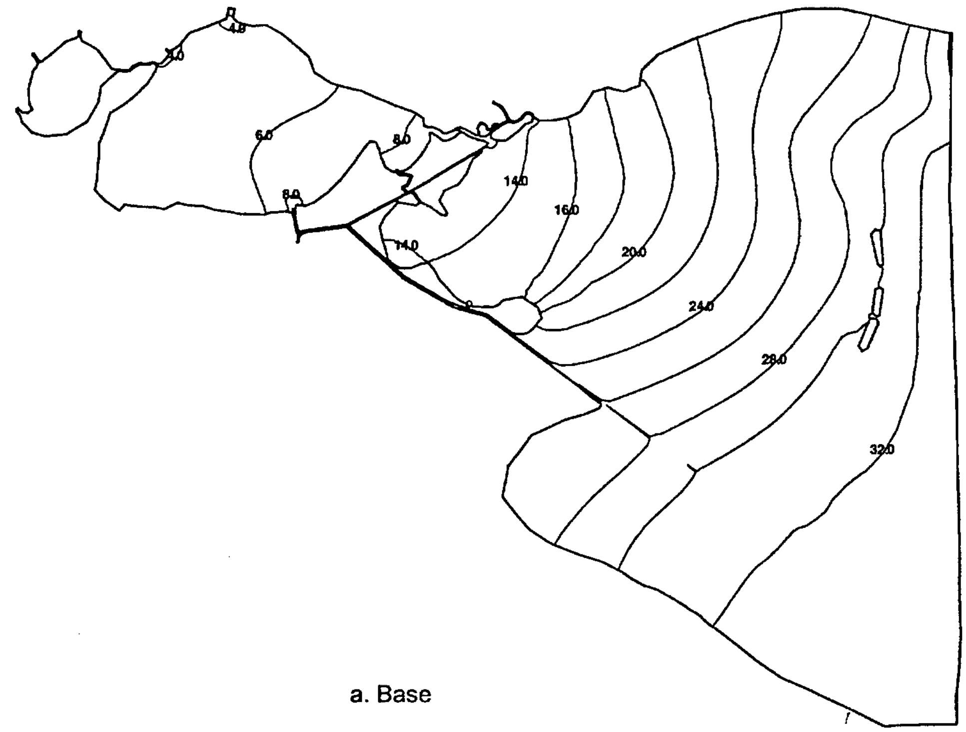
Plate 2
(Sheet 2 of 3)



e. Closure Plan

Pontchartrain Basin Isohalines
Base and Plans
May

Plate 2
(Sheet 3 of 3)



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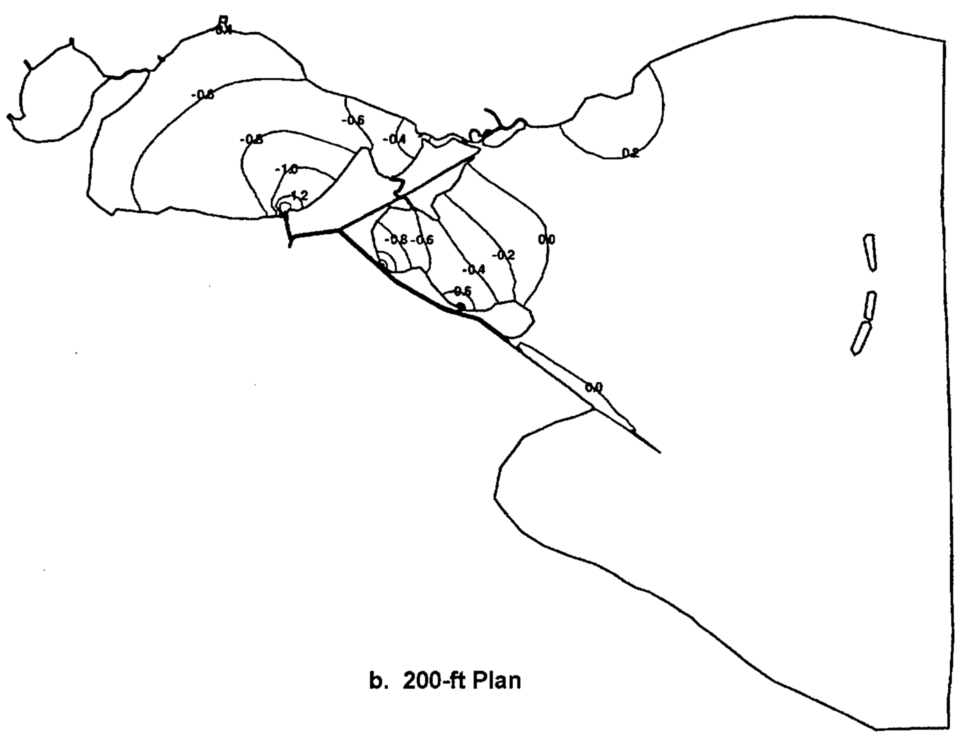
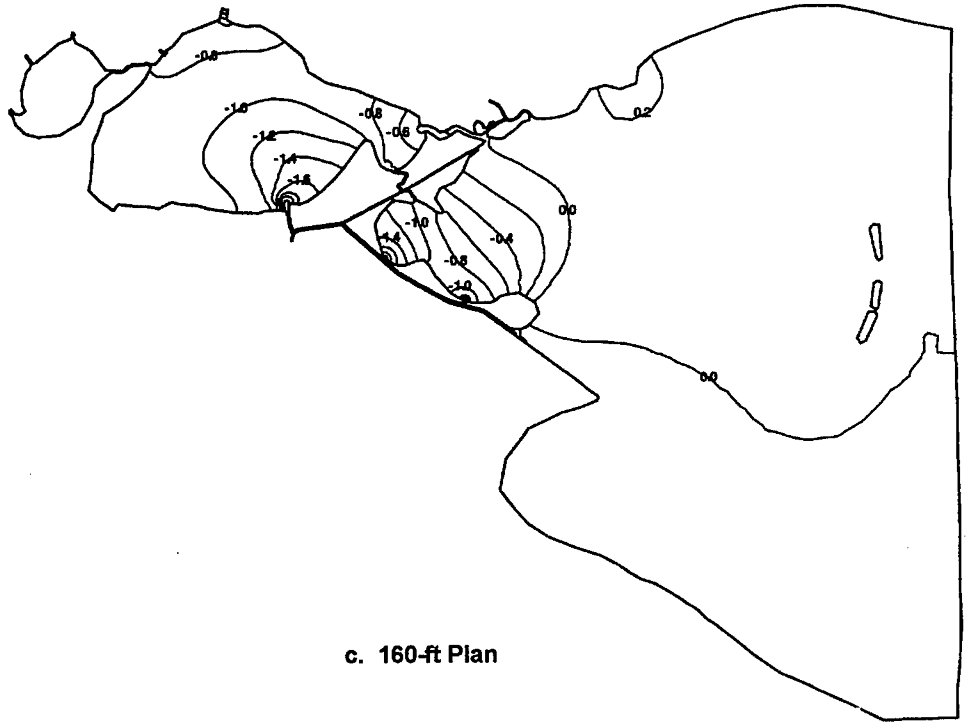


b. 200-ft Plan

Pontchartrain Basin Isohalines
Base and Plans
September

Plate 3
(Sheet 1 of 3)



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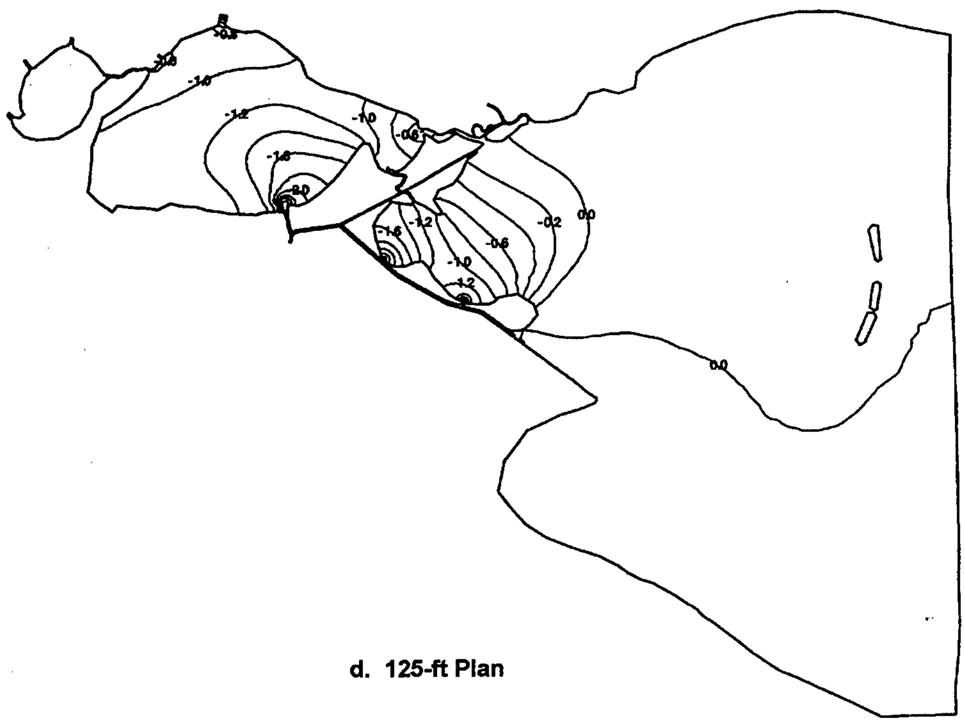
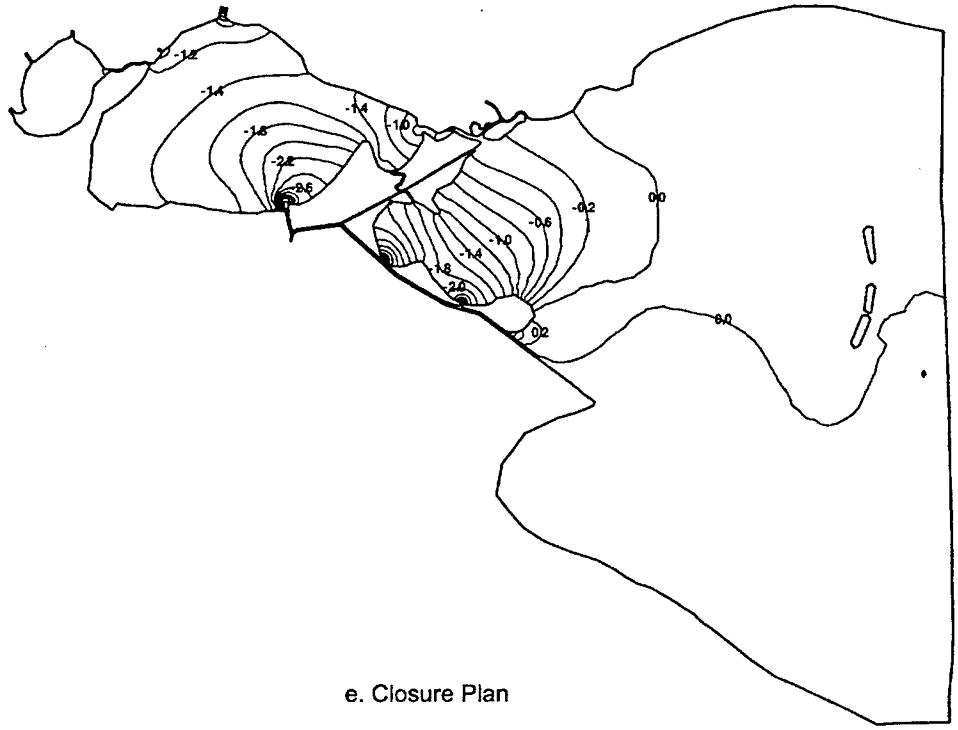


d. 125-ft Plan

Pontchartrain Basin Isohalines
Base and Plans
September

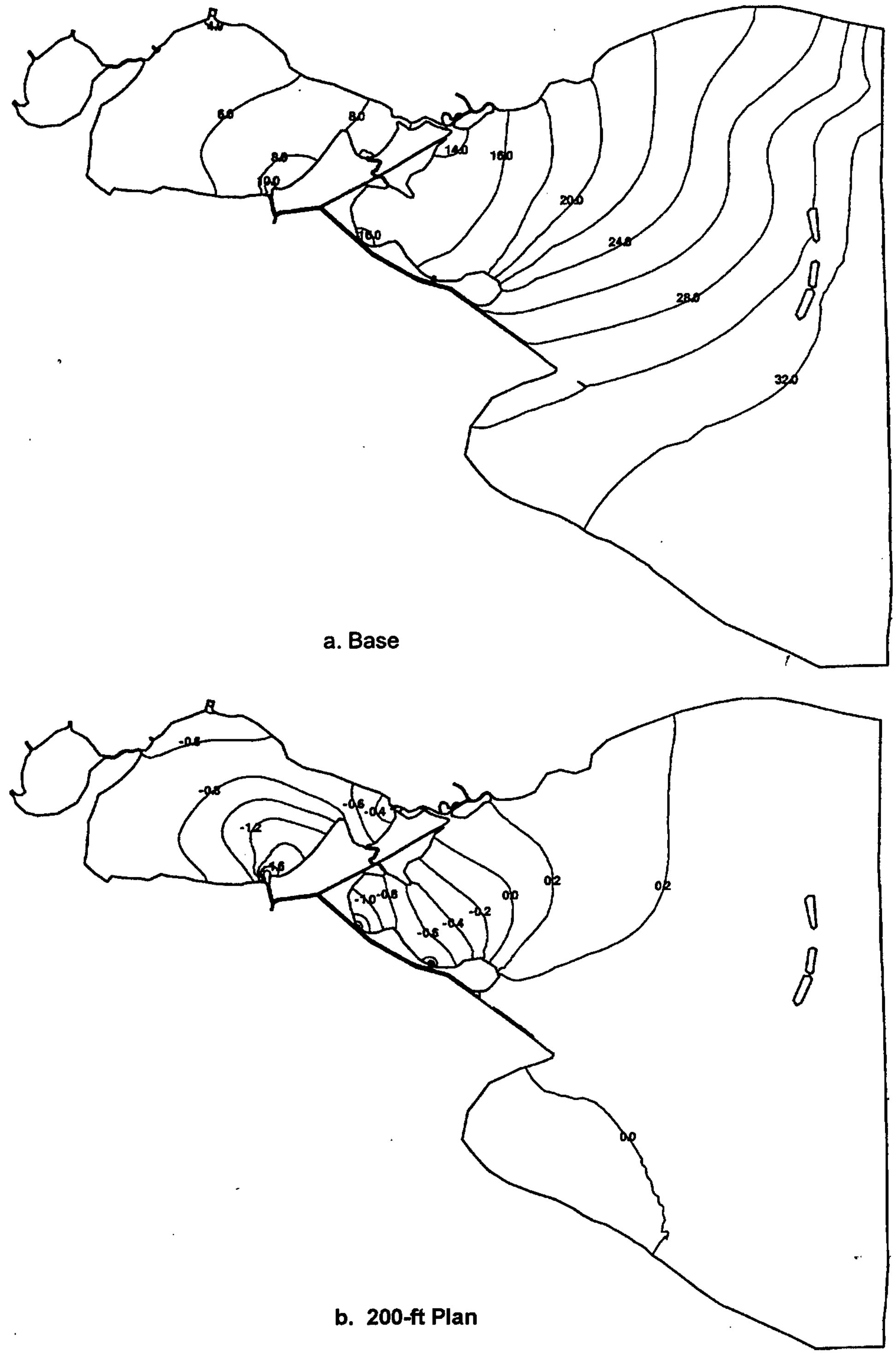
Plate 3
(Sheet 2 of 3)



e. Closure Plan

Pontchartrain Basin Isohalines
Base and Plans
September

Plate 3
(Sheet 3 of 3)

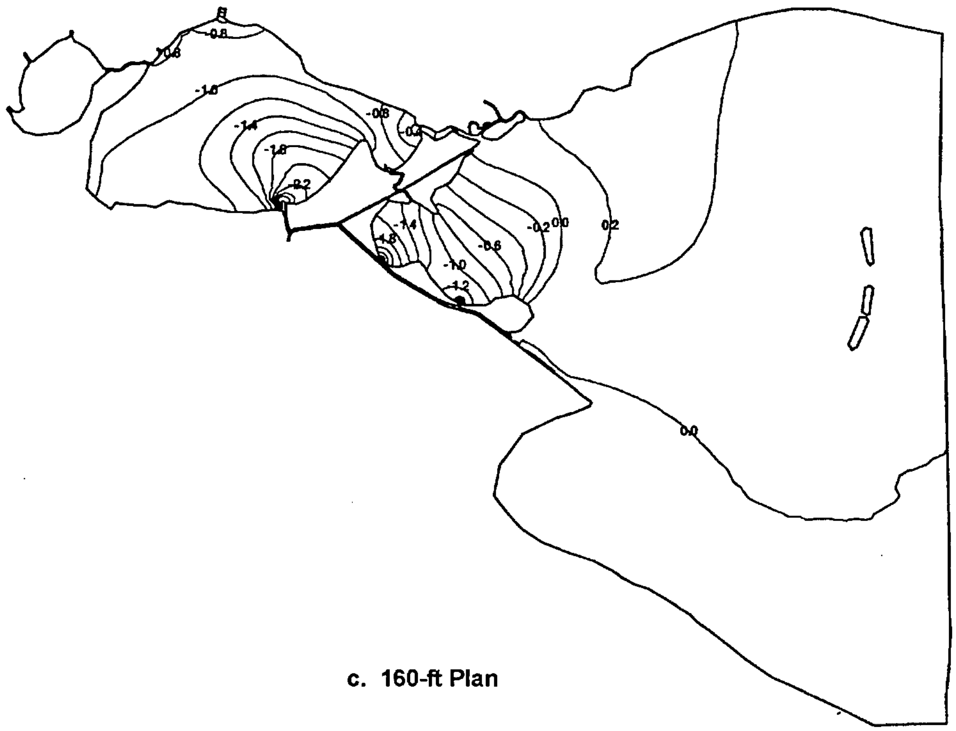


a. Base

b. 200-ft Plan

Pontchartrain Basin Isohalines
Base and Plans
October

Plate 4
(Sheet 1 of 3)



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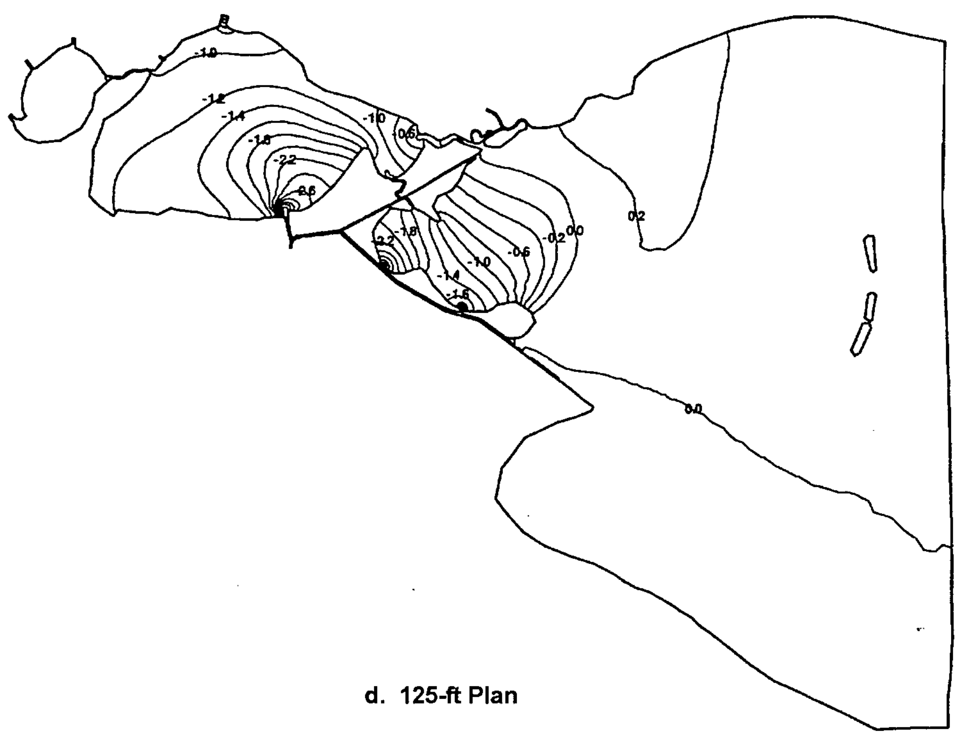
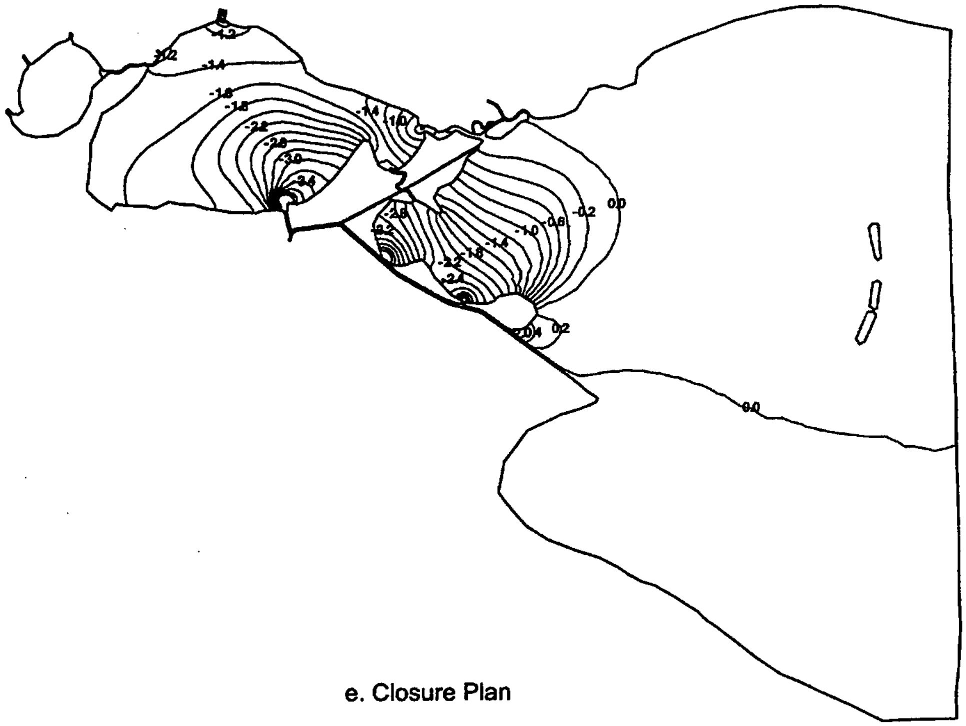


d. 125-ft Plan

Pontchartrain Basin Isohalines
Base and Plans
October

Plate 4
(Sheet 2 of 3)



e. Closure Plan

Pontchartrain Basin Isohalines
Base and Plans
October

Plate 4
(Sheet 3 of 3)

REPORT DOCUMENTATION PAGE

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6. AUTHOR(S) J. N. Tate, A. R. Carrillo, R. C. Berger, B. J. Thibodeaux		**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Engineer Research and Development Center Coastal and Hydraulics Laboratory 3909 Halls Ferry Road Vicksburg, MS 39180-6199		**8. PERFORMING ORGANIZATION REPORT NUMBER** ERDC/CHL TR-02-12
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14. ABSTRACT

The Mississippi River-Gulf Outlet (MRGO) consists of a ship channel 36 ft deep and 500 ft wide, extending approximately 76 miles from the juncture of the Inner Harbor Navigation Channel and the Gulf Intracoastal Waterway in New Orleans, LA, to the -38 mlw (mean low water) -ft contour in the Gulf of Mexico. The purpose of the MRGO is to provide a deep-draft channel to the Port of New Orleans Inner Harbor Facilities. Since the MRGO's completion in January 1968, saltwater flux from the MRGO through direct connections to Lake Borgne and the Gulf Intracoastal Waterway has contributed to an increase in the salinity concentration of the lakes and Biloxi Marshes. This report presents the results of a numerical model investigation used to predict average salinity changes that will occur in the Lake Pontchartrain Basin as a result of varying levels of depth and width closure of the MRGO below Lake Borgne. This report follows a previous study, ERDC/CHL TR-01-14, that modeled depth closure alone, which produced very low changes in salinity.

15. SUBJECT TERMS
Gulf Intracoastal Waterway — Mississippi River
Gulf outlet — MRGO

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